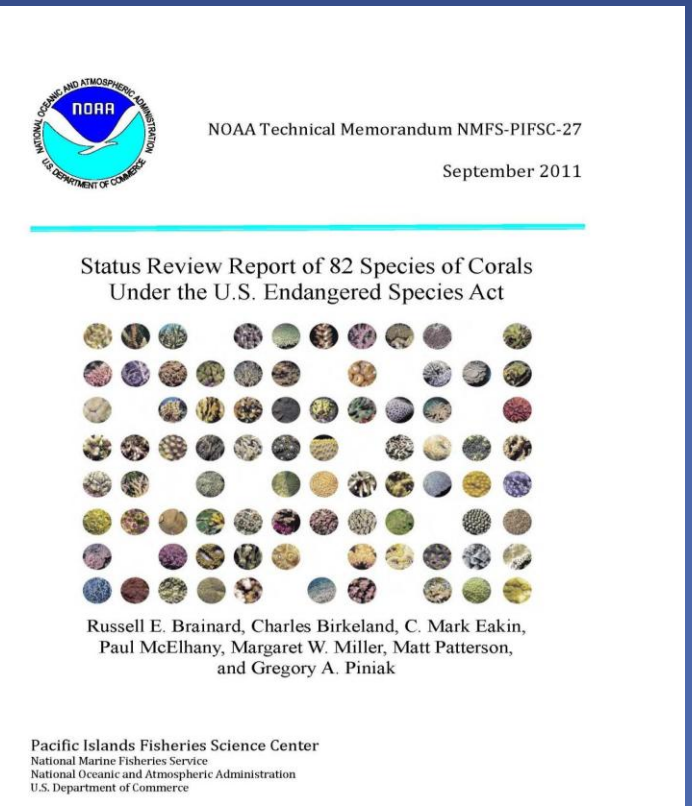
Summary of Biological Status Review of Climate Change Risks to Corals



NOAA Technical Memorandum NMFS-PIFSC-27

September 2011

Status Review Report of 82 Species of Corals Under the U.S. Endangered Species Act

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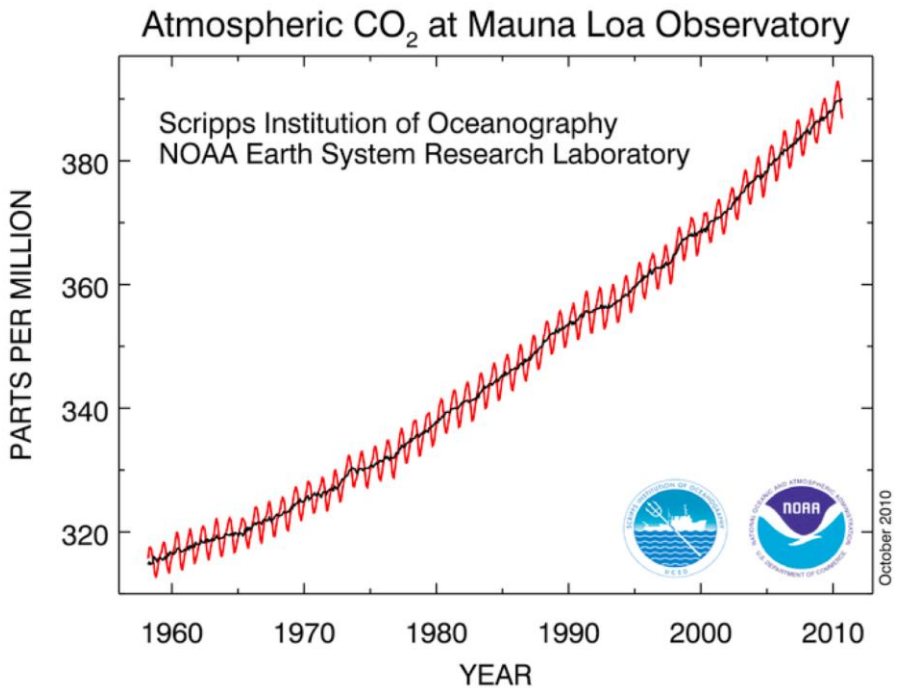
&
Biological Review Team

Evaluation of Extinction Threats

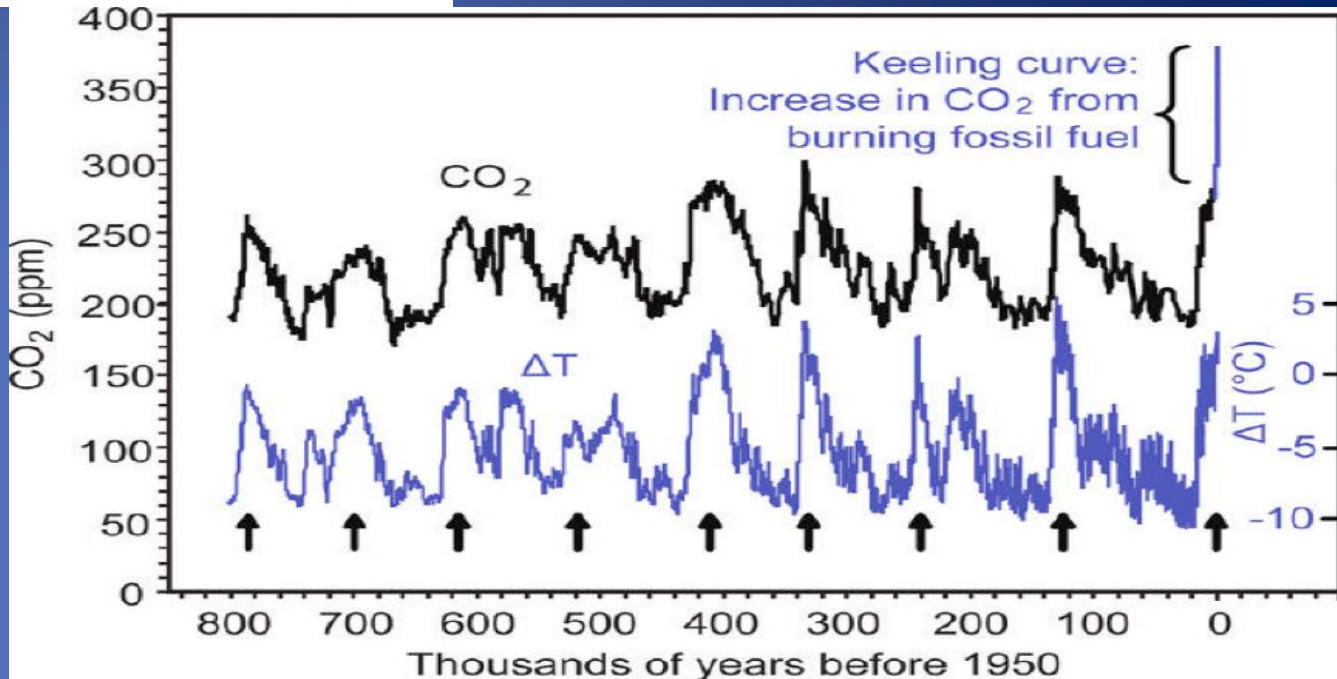
Threat	Importance
Ocean warming	high
Disease	high
Ocean acidification	med-high
Fishing- trophic effects	medium
Sea-level rise	low-medium
Sedimentation	low-medium
Nutrients	low-medium
Changing circulation	low
Changing storms	low
Predation	low
Fishing - destructive practices	low
Physical damage - storms	low
Coastal construction	low
Aquarium and curio trade	low
Toxins*	not neglibile
Invasive species	neglible-low
Insolation*	probably negligible
Salinity	negligble
Dust	negligible
Physical damage - debris	negligible
Physical damage - tourism/divers	negligible
Physical damage - vessels	negligible

Highlights

- Ocean warming is a clear and present threat to corals and coral reefs
- Ocean acidification is likely to be a major threat in coming decades
- Other climate threats are concerns, but have limited extinction risk
- The pervasive nature of climate threatens even the best managed and most remote reefs
- Climate change a major reason that most of the 82 candidate coral species are 'more likely than not' to fall below the Critical Risk Threshold by 2100.



Carbon dioxide is rising and is now at highest levels in over 800,000 and probably 24 million years



Anthropogenic carbon dioxide emissions are accelerating and near or exceeding worst-case scenarios used in IPCC 4th Assessment Report (2007)

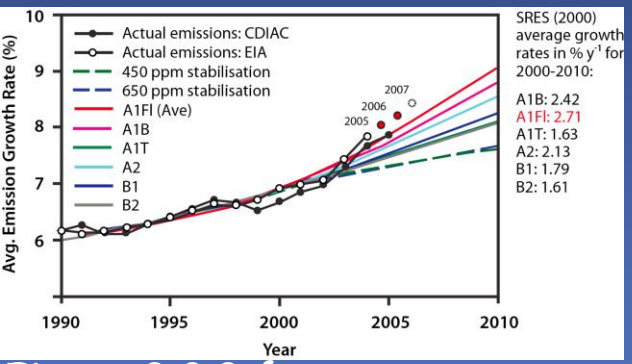
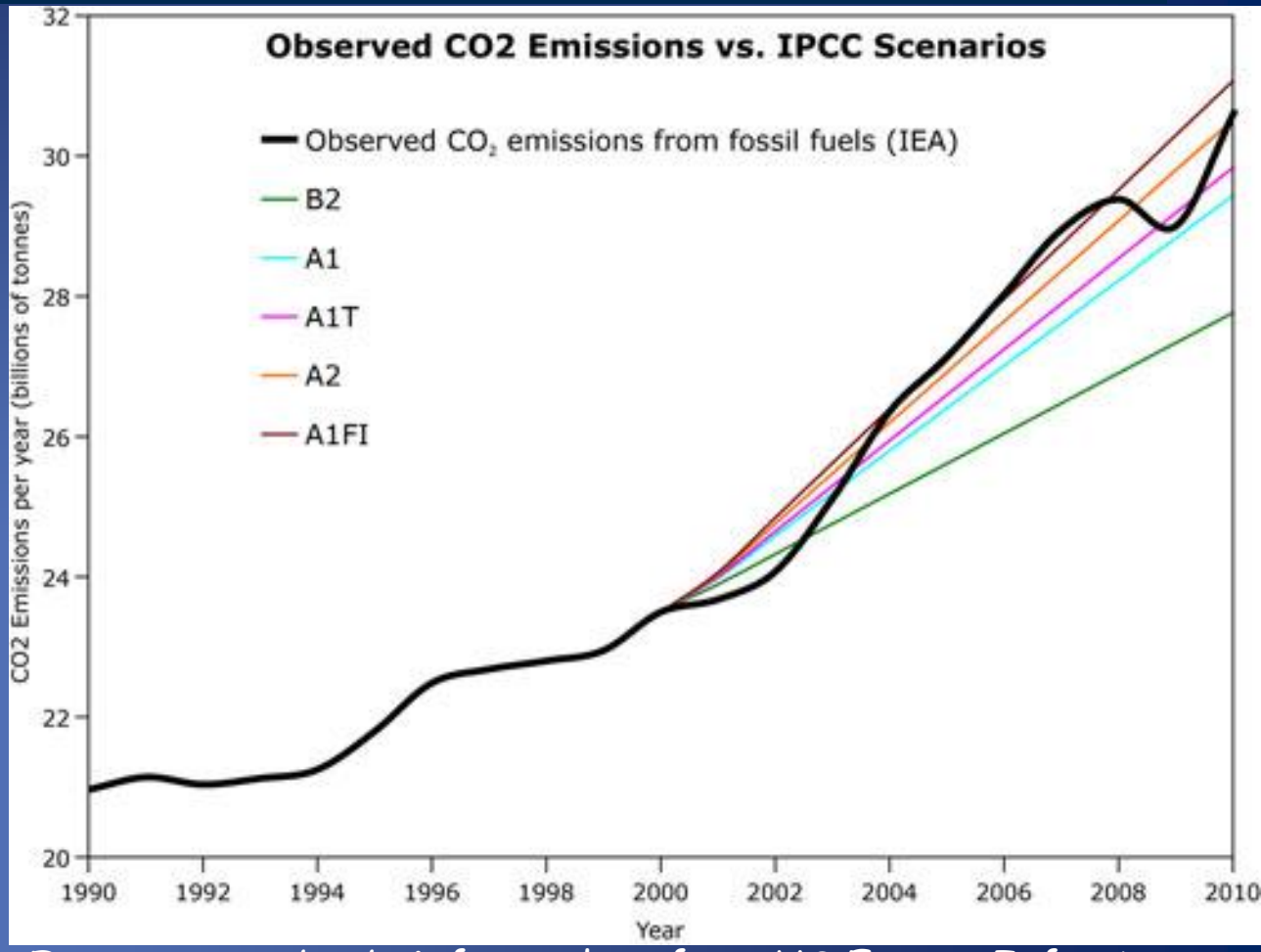


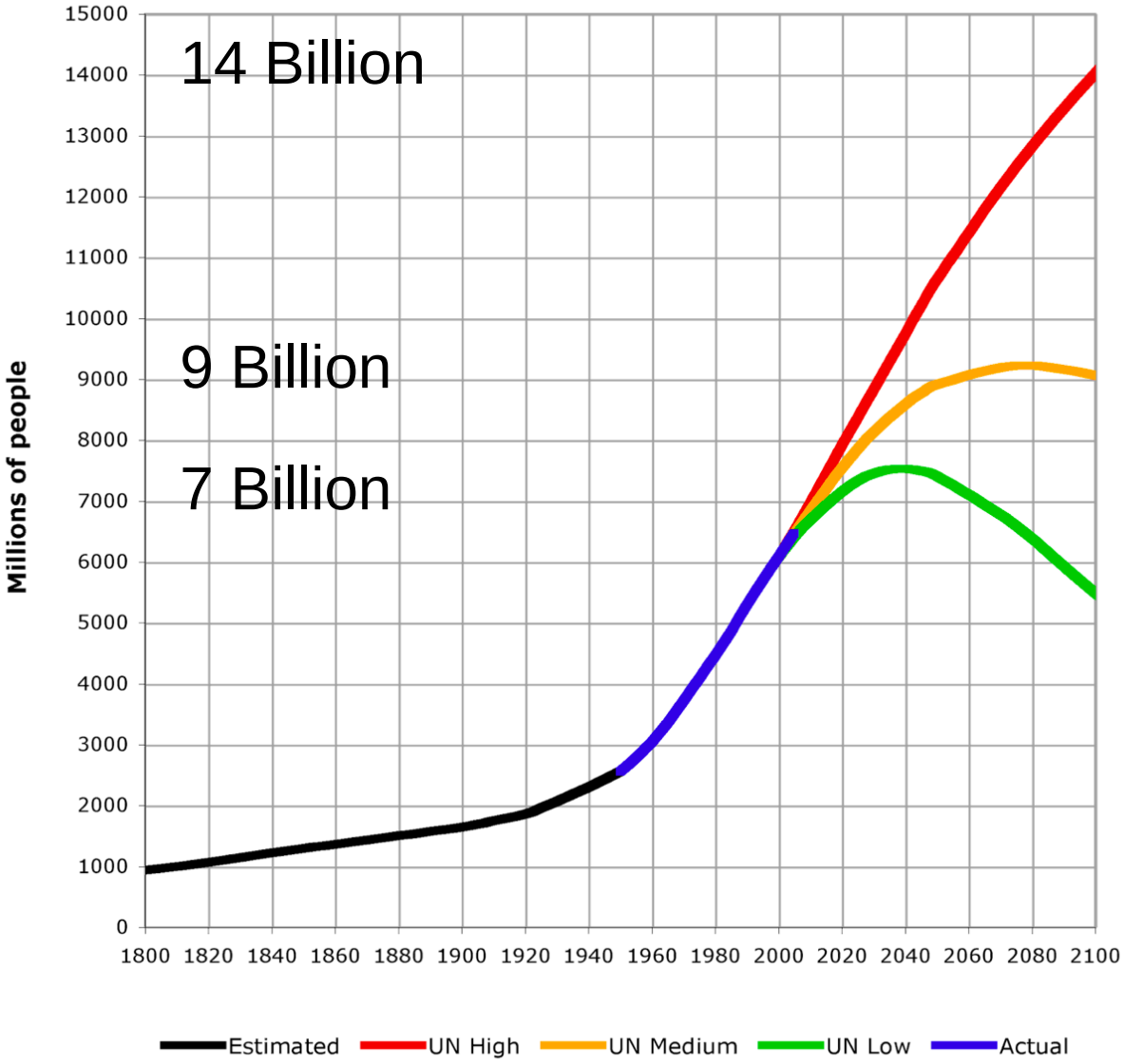
Figure 3.2.3 from Brainard et al. 2011



From www.carbonbrief.org, data from US Energy Info. Agency

Primary drivers:

- Too many people

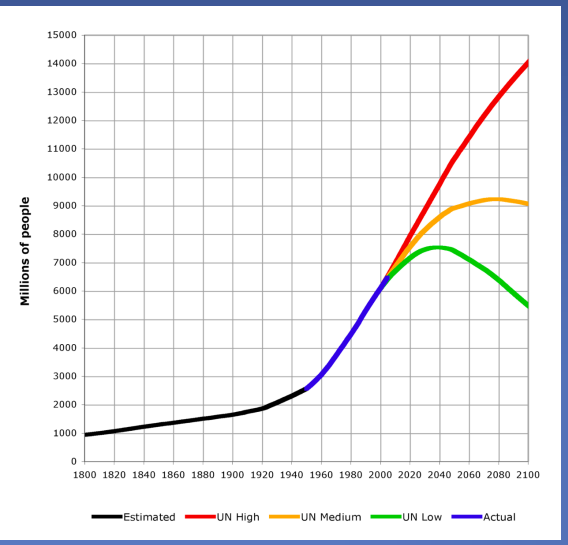


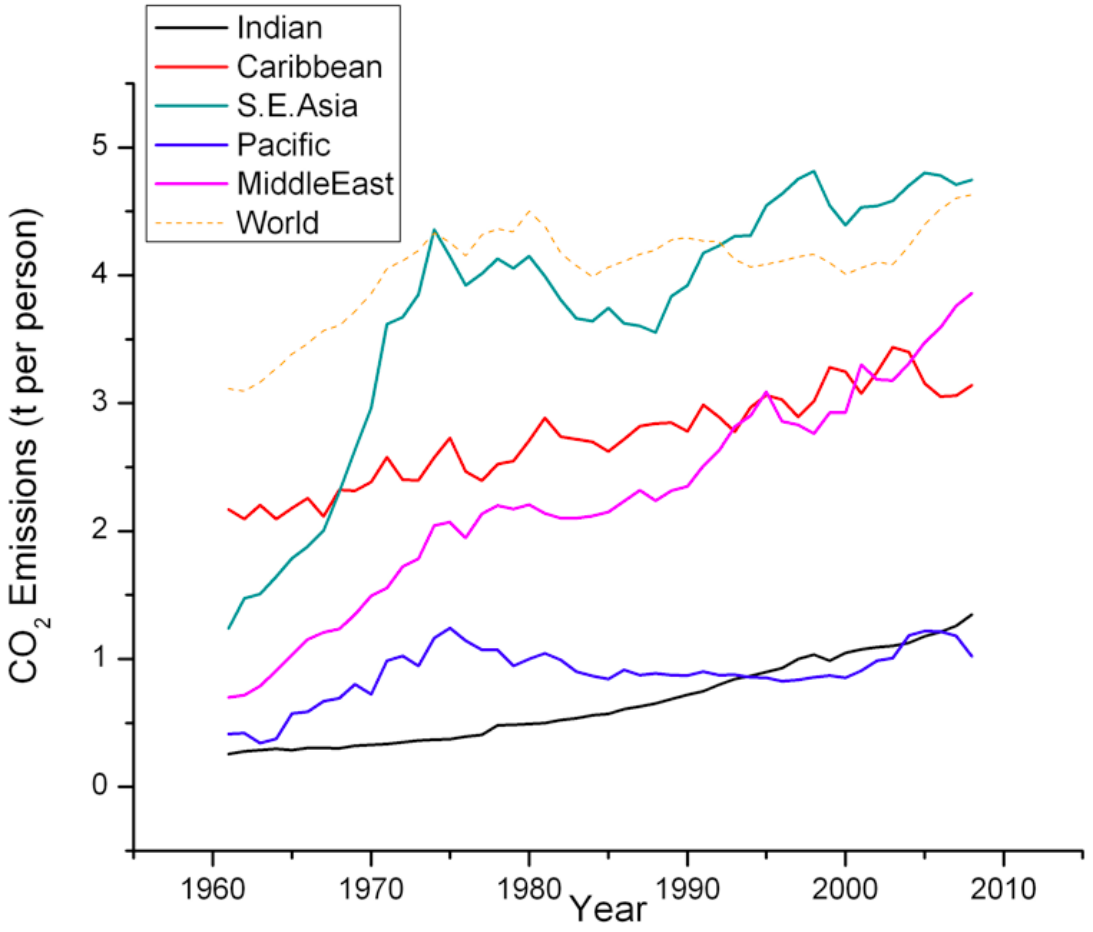
Human population over 7 billion, expected to reach 9 billion around 2030, perhaps double by end of century

Primary drivers:

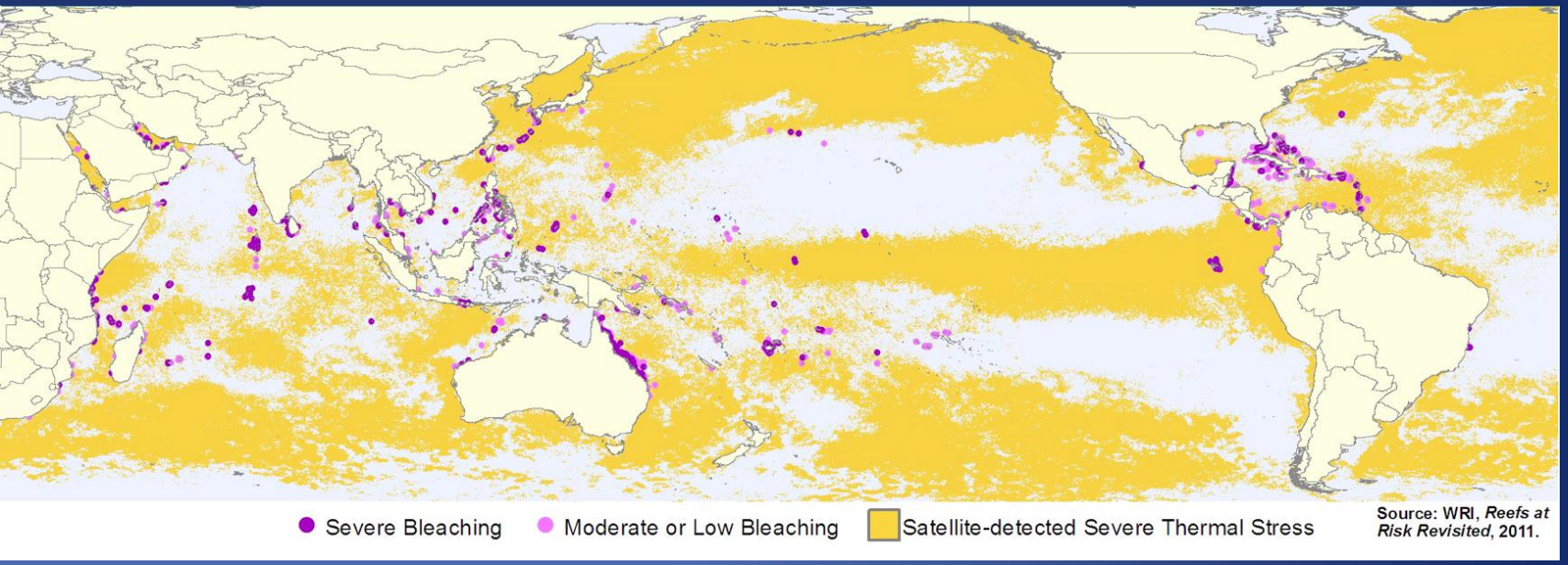
- Too many people
- Too much consumption

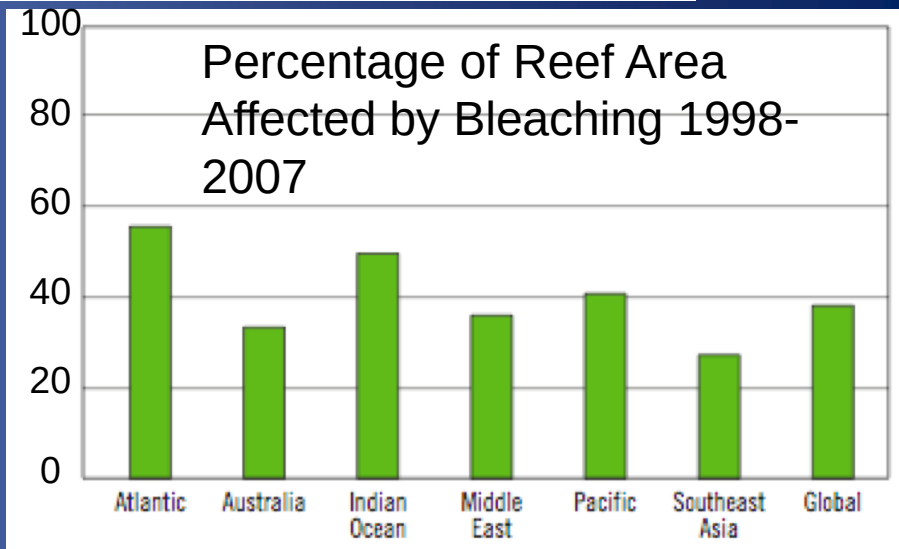
Per capita emissions rising rapidly as well



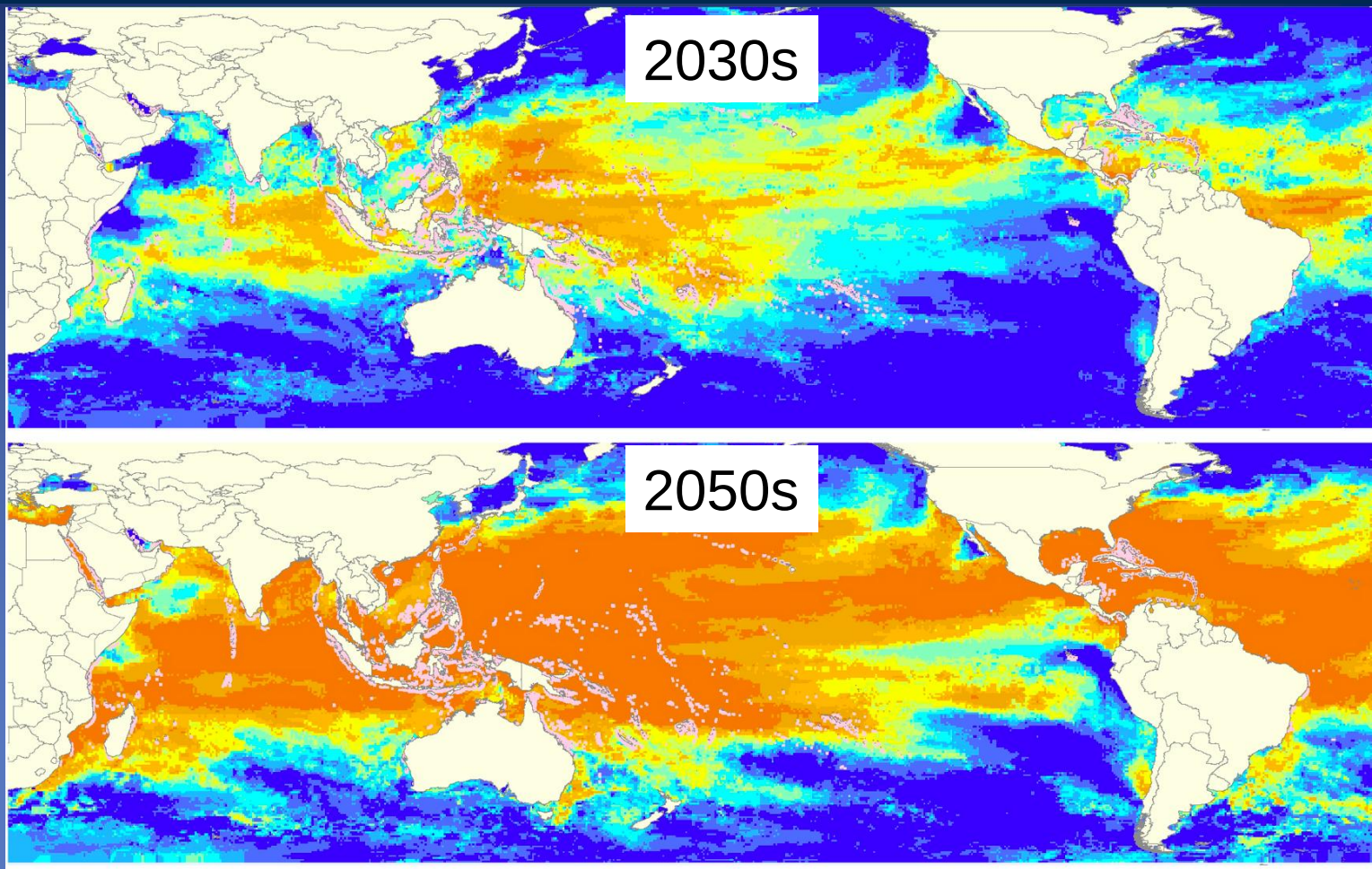


Rising temperatures have already caused widespread bleaching and mortality





Ocean temperatures around reefs likely to rise 0.8°C by 2030s, 2.8°C by 2100, increasing bleaching frequency and intensity

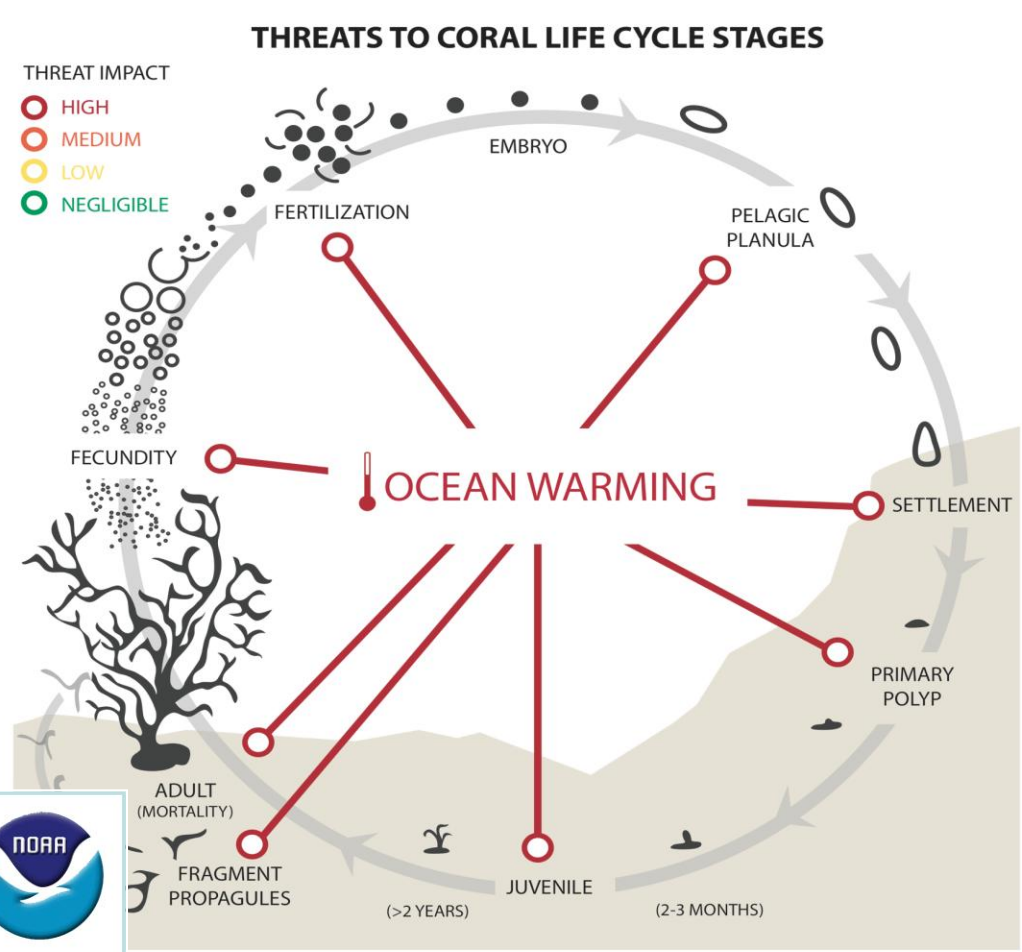


Source: Adapted from Donner, S.D. 2009. "Coping with Commitment: Projected thermal stress on coral reefs under different future scenarios." PLoS ONE 4(6): e5712 for use in the *Reefs at Risk Revisited* project.

Other Impacts of Warming

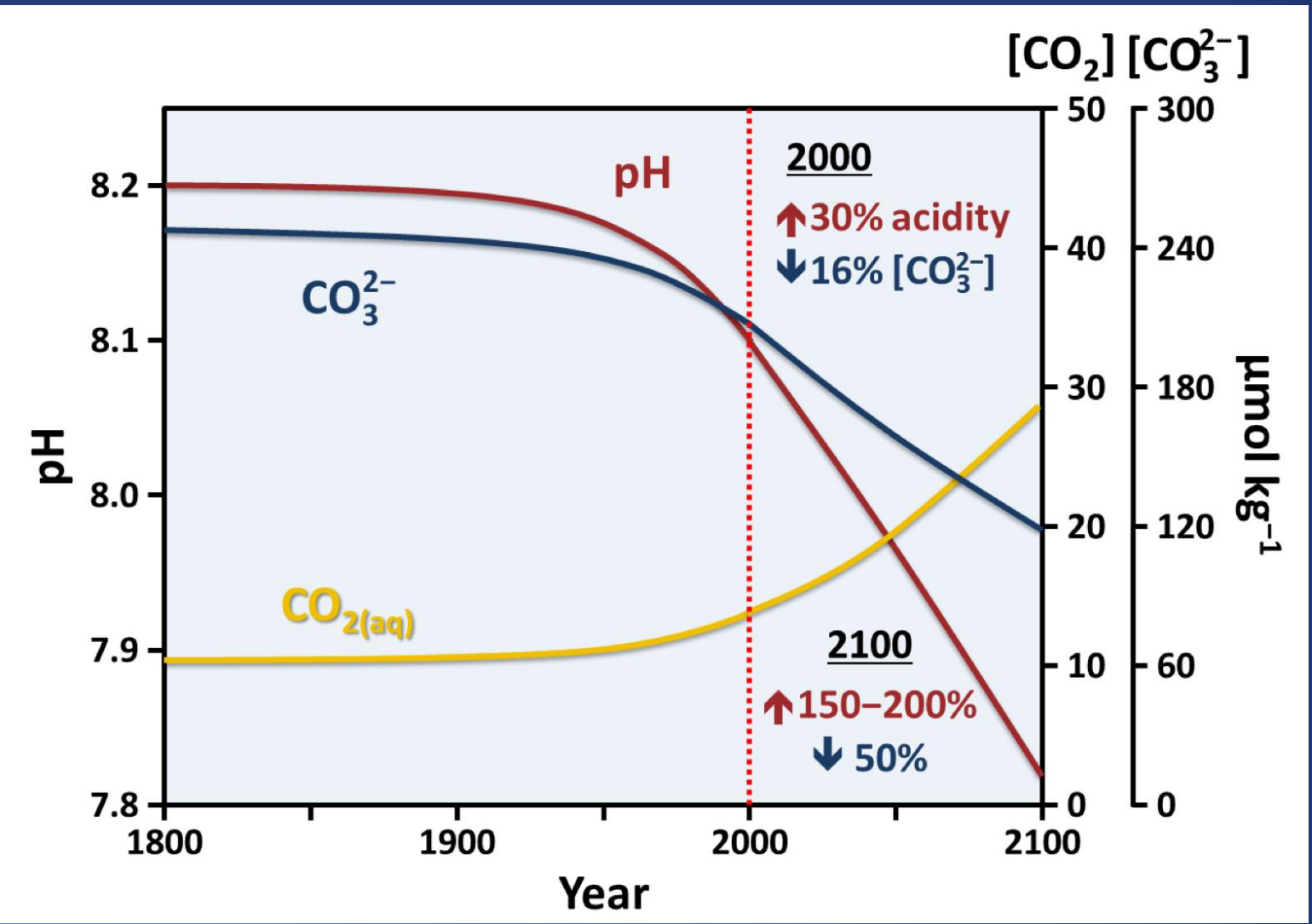
- Strong relationship between rising temperatures and increase in coral diseases
- Evidence high temperatures impair reproductive success
- Warming is leading to increased stratification and oligotrophy
- Potential for range shifts
  - Good news: some corals demonstrating range shifts
  - Bad News: poleward movement of corals likely limited by other factors
- Reduced reef resilience

Warming a threat to all coral life cycle stages



Threat HIGH

Rising CO_2 also reducing carbonate concentrations and pH



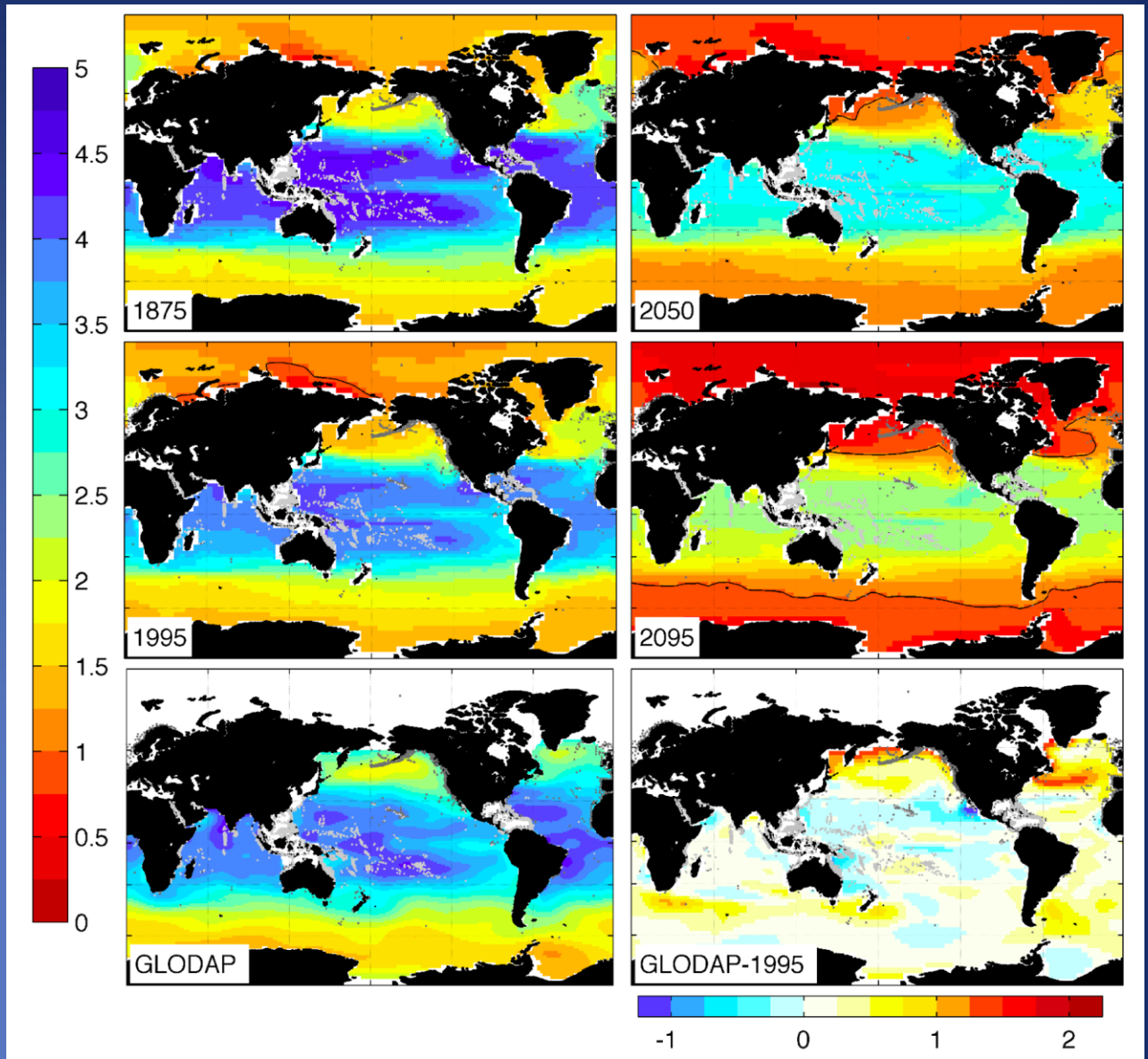
Rising CO_2 also reducing carbonate concentrations and pH

optimal

adequate

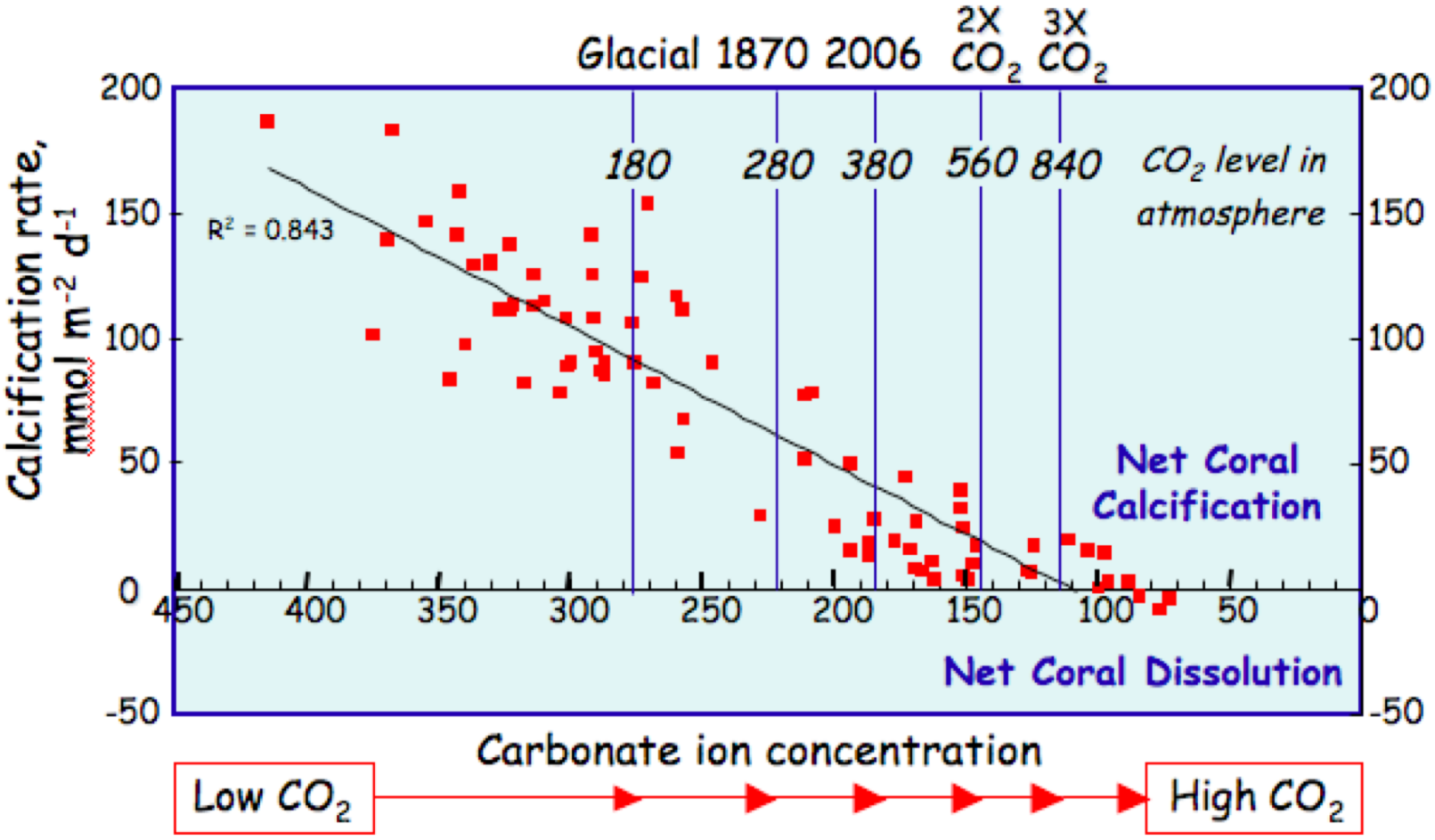
marginal

poor



Rising CO_2 also reducing carbonate concentrations and pH

causing reduced calcification and reef growth



Impacts of Acidification

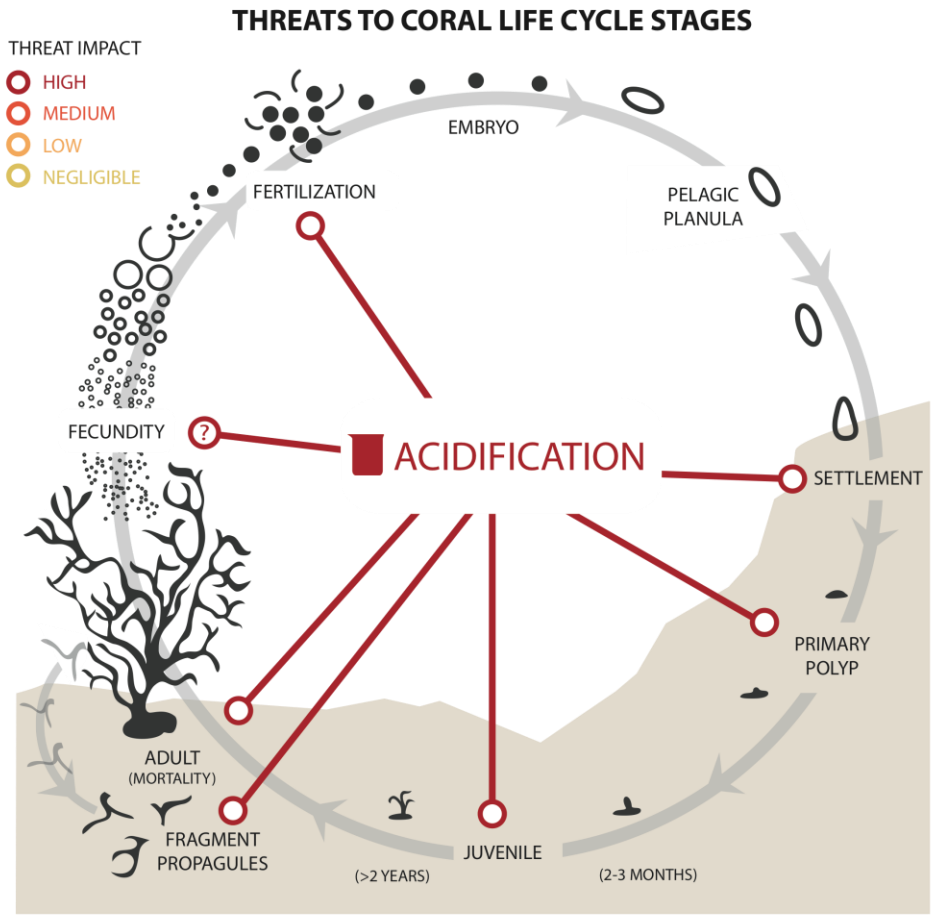
Genus (Atlantic)	Response to elevated CO_2	Response Direction
Acropora cervicornis	Decreased growth rate	↓
Acropora palmata	Decreased fertilization, settlement, post-settlement growth	↓
Porites astreoides	Decreased calcification by recruits	↓
Favia fragum	Decreased calcification by recruits	↓
Oculina arbuscula	Decreased calcification by adults	↓

Extracted from table in Brainard et al 2011

Other Impacts of Acidification

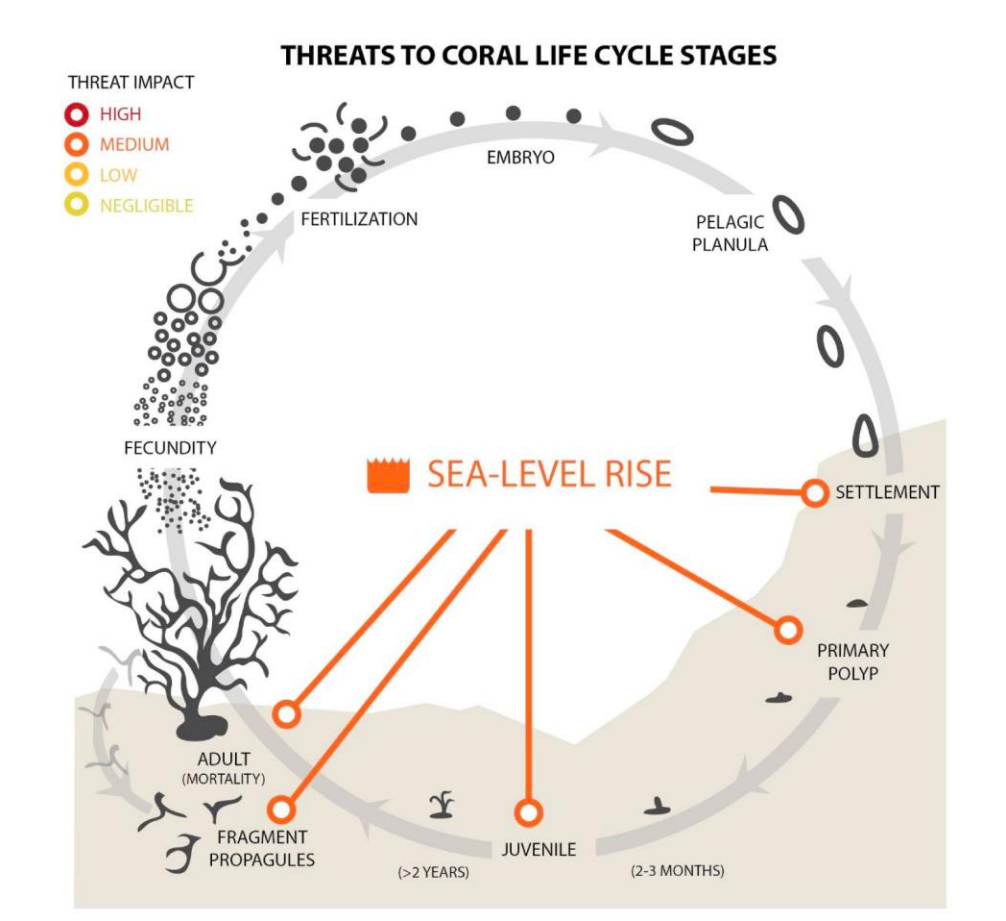
- Decreased cementation
- Increased bioerosion and chemical erosion
- Evidence acidification impairs reproductive success
- Even stronger impact on coralline algae with important role in coral settlement
- Reduces detection of reefs by coral larvae
- Reduced reef resilience

Threat
Med-High



Ocean acidification probably a threat to all coral life cycle stages

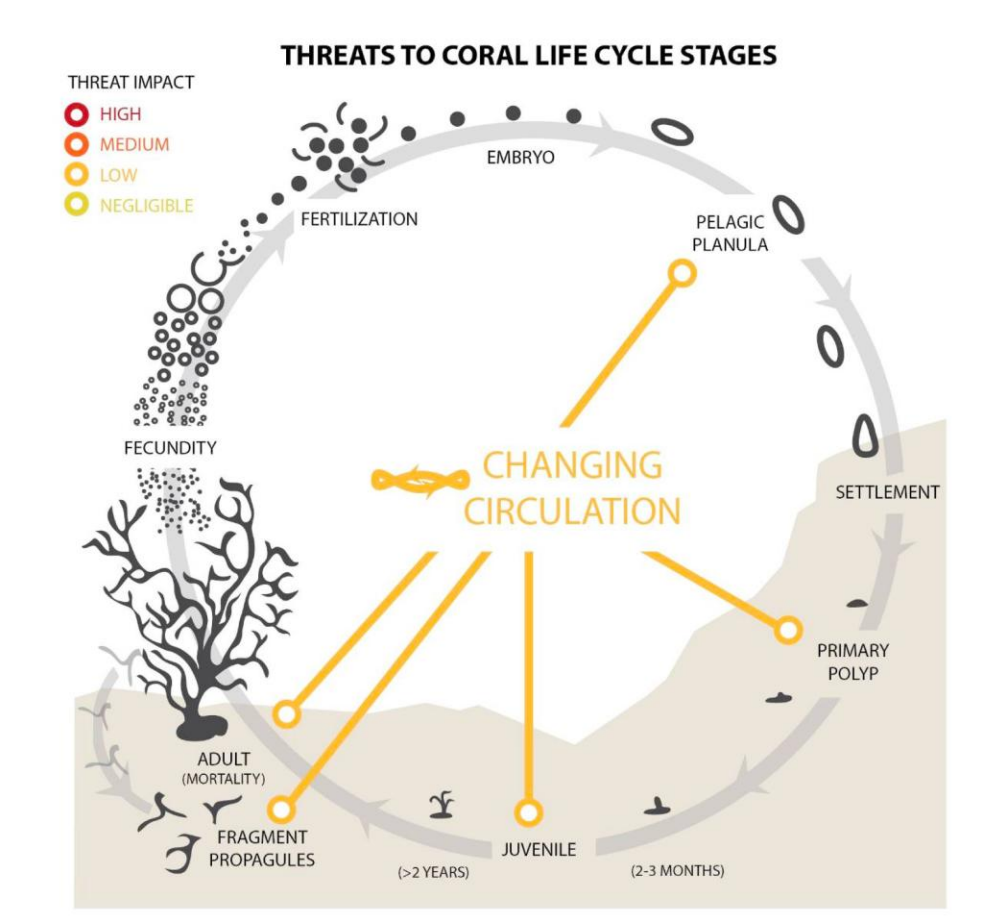
Other Climate Threats: Sea level rise of 1-2 m by 2100 most likely



Threat Low-Medium

Other Climate Threats:

Changing circulation most likely to influence connectivity



Threat Low

Other Climate Changes

- Changing storm tracks and intensities — Threat Low
- African and Asian dust — Threat Negligible
- Changes in insolation — Threat Negligible

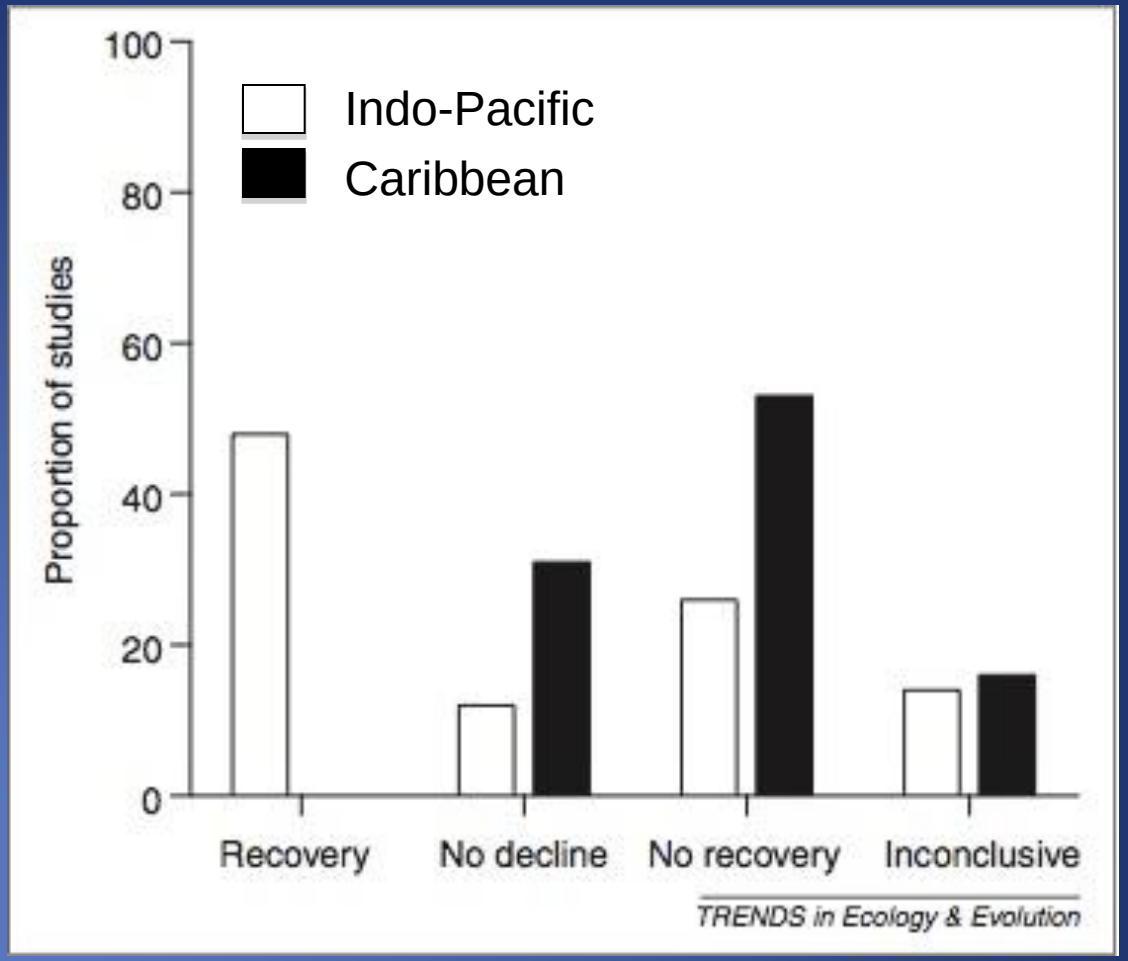
- Interactions of any climate change threats with other threats can increase risk from both

Geographic Variability of Climate Change Threats

	Indo-Pacific	Eastern Pacific	Western Atlantic
Coral Genera	91	10	25
Coral species	~ 700	40	65
Concentration of Thermal Stress	Varied	Very High	Medium-High in Gulf & Caribbean
Bleaching Impact	Generally lowest	Very high, probable extinction (*Millepora boschmai*)	High
Rate of Acidification	Generally lowest	Slow change, pH already low	Highest
Impact of Disease	Low	Uncertain	High

Table from information in Brainard et al 2011

Geographic Variability of Climate Change Threats



from Roff & Mumby 2012 *TREE*

Summary

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